This document includes Section 10.0, WPB 110 Class: Vessels with Compression Ignition Engines, Landing Craft, Coastal Mine Hunters, and Buoy Tenders, of the Draft EPA Report “Surface Vessel Bilgewater/Oil Water Separator Feasibility Impact Analysis Report” published in 2003. The reference number is: EPA-842-D-06-019

DRAFT
Feasibility Impact Analysis Report Surface Vessel Bilgewater/Oil Water Separator

Section 10.0 – WPB 110 Class: Vessels with Compression Ignition Engines, Landing Craft, Coastal Mine Hunters, and Buoy Tenders

2003

SECTION 10.0 – WPB 110 CLASS

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10.0 WPB 110 CLASS

The U.S. Coast Guard's WPB 110 Class of patrol boats was selected to represent the group of small compression ignition powered ships between 65 and 200 feet in length. There are 49 vessels within the WPB 110 vessel class. WPB 110 Class vessels operate approximately 14 days annually beyond 12 nautical miles (nm) of shore and spend approximately14 days annually out of the water (Navy and EPA, 2003). The total volume of bilgewater generated within 12 nm is calculated by adding the volume of bilgewater generated in port to the volume generated while operating within 12 nm. WPB 110 Class vessels spend approximately 268 days pierside, and another 69 days operating within 12m, for a total of 337 days within 12 nm of shore annually (Navy and EPA, 2003). The in-port bilgewater generation rate is approximately 4 gallons per day (gpd), and the underway rat (both transiting within and beyond 12 nm) is 25 gpd (Navy and EPA, 2003). Each vessel in this class generates approximately 2797 gallons of bilgewater within 12 nm and 350 gallons of bilgewater beyond 12 nm annually.

Bilgewater generated within 12 nm:

$$\frac{268 \text{ days (pierside)}}{\text{yr}} \bullet \frac{4 \text{ gal}}{\text{day}} + \frac{69 \text{ days (underway)}}{\text{yr}} \bullet \frac{25 \text{ gal}}{\text{day}} = 2{,}797\text{gal/yr}$$

Bilgewater generated beyond 12 nm:

$$\frac{14 \text{ days (underway)}}{\text{yr}} \bullet \frac{25 \text{ gal}}{\text{day}} = 350 \text{ gal/yr}$$

WPB 110 Class vessels use a 2 gallons per minute (gpm) gravity coalescence type oil water separator (OWS) (Sarex model VGS-2) to process bilgewater, consequently this option is the current marine pollution control device (MPCD). WPB 110 Class vessels use one 120-gpm oily waste transfer (OWT) pump and one 8-gpm waste oil transfer pump for offloading oily wastewater and waste oil to shore facilities (Bindal, 2000b). The 8-gpm waste oil transfer pump will be used for each MPCD analysis except for the collection holding and transfer (CHT) MPCD.

Where appropriate, the current MPCD was used to determine the operational capacities and other parameters used to evaluate each of the MPCDs in the feasibility analysis. The following MPCDs are evaluated for WPB 110 Class vessels: gravity coalescence; centrifuge; collection, holding and transfer (CHT); evaporation; hydrocyclone; *in situ* biological treatment; oil absorbing socks; filter media; and membrane filtration.

10.1 GRAVITY COALESCENCE

The following sections describe the feasibility and cost impacts of installing and operating a gravity coalescence unit on-board WPB 110 Class vessels.

10.1.1 Practicability and Operational Impact Analysis

This section describes the analyses of specific feasibility criteria relative to the physical characteristics and operational requirements of gravity coalescence units.

10.1.1.1 Space and Weight

As described in Section 10.1, the analysis of gravity coalescence will include one 2-gpm Sarex VGS-2 gravity coalescence unit and one 8-gpm waste oil transfer pump. The Sarex VGS-2 is intended for single-deck operation and is commonly placed in a machinery space, in the vicinity of the oily waste holding tank (OWHT). Table 10-1 provides the space and weight for the 2-gpm Sarex unit.

Table 10-1. Sarex VGS-2 Specifications (WPB 110 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	2 gpm	2.5 x 2 x 2.5	4.5 x 4 x 4.75	12.5	132/190
Total (To achieve required processing capacity)	1	2 gpm	-	-	12.5	132/190

Clearance is required above the OWS tank assembly to mount chain falls for removal of the tank cover and filter cartridges.

10.1.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with gravity coalescence units. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use on-board vessels of the Armed Vessels. Standard control and management procedures are adequate for use and disposal of the material. While gravity coalescence units require electrical power, observing standard shipboard safety procedures for handling electrical equipment is adequate to protect personnel safety.

10.1.1.3 Mission Capabilities

The use of the SAREX VGS-2 on WPB 110 Class vessels has not resulted in any impact on ship’s signature, war-fighting capabilities, mobility, or on any mission critical systems or operations.

10.1.1.4 Personnel Impact

The SAREX VGS-2 separator runs in automatic mode, but requires general supervision while the unit is operating. Based on an MPCD rated capacity of 2.0 gpm, and the estimated 2,797 gallons of bilgewater generated annually within 12 nm of shore, the number of hours the gravity coalescer is operated annually within 12 nm is approximately 23 hrs/yr.

$$\frac{2{,}797\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{2\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 23\text{ hrs/yr}$$

The personnel hours required per year for operation of the Sarex VGS-2 separator equals 15 minutes (0.25 hours) for every two hours the unit operates. The supervisory labor requirement of 15 minutes for every two hours of operation is based on the assumption that although the unit is automatic, one crewmember will be assigned to general oversight of multiple pieces of equipment at once. Based on the annual operating requirement of 23 hours, the annual labor requirement associated with the operation of gravity coalescence, within 12 nm is 2.9 hours, as calculated below:

$$\frac{23\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hrs}} = 2.9\text{ hrs/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event. One crewmember is required to operate the waste oil transfer pump and associated valves/hull connections. A second crewmember is required to oversee the connection of transfer hoses for the offloading vessel. A third crewmember oversees the connection of transfer hoses for the receiving vessel or facility. The two crewmembers overseeing the transfer hoses stand near the hose connections in case the connections separate. The two crewmembers overseeing the transfer generally ensure that appropriate precautions are taken to prevent oil leaks and spills. During waste oil transfer activities, two-way voice communication must be established between the three crewmembers overseeing the oil transfer (Navy, 2002). The labor hours associated with transferring the waste oil separated by a gravity coalescence unit on WPB 110 Class vessels within 12 nm of shore are calculated by dividing the waste oil volume (1 percent of the bilgewater volume generated while operating within 12 nm of shore, i.e., 27.97 gal) by the waste oil pump rate (8.0 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{27.97\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{8\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \frac{3\text{ hrs labor}}{\text{hr}} = 0.17\text{ labor hrs/yr}$$

The combined annual labor associated with the operational oversight of the gravity coalescence unit within 12 nm and transfer of waste oil generated within 12 nm on a WPB 110 Class vessel is 3.1 hours.

The total labor requirement associated with gravity coalescence operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. The volume (i.e., 350 gal) of bilgewater generated beyond 12 nm and resultant volume (i.e. 3.5 gal) of waste oil that requires offloading to shore are based on the WPB 110 Class vessel underway bilgewater generation rate of 25 gpd. The underway generation rate is multiplied by the number of days (28 days) spent beyond 12 nm. Hours of MPCD operation and annual labor requirements are presented below.

Hours of MPCD operation beyond 12 nm:

$$\frac{350\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{2\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 2.9\text{ hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{2.9\text{ hrs}}{\text{yr}} \bullet \frac{0.25\text{ hrs labor}}{2\text{ hrs}} = 0.36\text{ hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{3.5\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{8\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hrs}} = 0.02\text{ hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of a Sarex 2-gpm VGS-2 gravity coalescence unit on a WPB 110 Class vessel beyond 12 nm is .39 hr/yr.

Annually, the Sarex VGS-2 requires approximately 1 personnel hour of time-based preventive maintenance per year, 0 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 10-2 and Table 10-3 summarize the time-based maintenance and condition-based maintenance requirements, respectively for one SAREX VGS-2.

Table 10-2. Sarex VGS-2 Time-Based Maintenance (WPB 110 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Operational Check of OWS (includes operational observation and filter element replacement if necessary)	0.25	3 months	1
Total Annualized Hours (per unit)	-	-	1
Total Annualized Hours (total)	-	-	1

Table 10-3. Sarex VGS-2 Condition-Based Maintenance (WPB 110 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on 23 operation hours within 12 nm)	Annualized Maintenance Hours (based on 2.9 operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours (per unit)	-	-	-	0
Total Annualized Hours (per vessel)	-	-	-	0

Table 10-4 provides the annual labor hours required to operate and maintain the gravity coalescer.

Table 10-4. Gravity Coalescence Annual Labor Hours (WPB 110 Class)

	Sarex VGS-2 Gravity Coalescence
Operator Hours Within 12 nm	3.1
Operator Hours Beyond 12 nm	0.39
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	1.0
Total Time	4.5

10.1.1.5 Consumables, Repair Parts, and Tools

Gravity coalescence units installed on WPB 110 Class vessels do not require consumables. No special tools are required for the operation or maintenance of these units.

10.1.1.6 Interface Requirements

Table 10-5 provides specific system interface requirements associated with the Sarex VGS-2 OWS.

Table 10-5. Sarex VGS-2 Interface Requirements (WPB 110 Class)

Shipboard System	SAREX VGS-2
Electrical Power	110/220 VAC, 50/60 Hz, 1 Phase

10.1.1.7 Control System Requirements

The gravity coalescence units installed on-board the WPB 110 Class are designed to operate in either automatic or manual mode. Automatic operation is the normal operating mode. Units have a flow sensor that will secure the system if the pump loses suction and a remote alarm/indicator panel that allows shipboard personnel to monitor the operating status of the units while in the automatic mode of operation. The remote alarm/indicator contains visual indicators that allow operating personnel to monitor the overall status of the system and an audible alarm that warns of system malfunction.

If the oil content monitor (OCM) detects an oil concentration greater than the predetermined desired concentration, the OCM will redirect the effluent back to the OWHT to be processed again by the OWS.

10.1.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

10.1.2 Cost Analysis

The following cost data and calculations are provided to allow the reader to compare relative costs associated with a gravity coalescence system on a WPB 110 Class vessel.

10.1.2.1 Initial Cost

There are no initial costs associated with gravity coalescence on a WPB 110 Class vessel because the equipment is in place as described above.

10.1.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 4.1 personnel hours per year for operation and time-based maintenance within 12 nm, as explained under Section 10.1.1.4. The number of annual labor hours multiplied by the \$22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{4.1\ \text{hrs}}{\text{yr}} = \$93/\text{yr inside } 12\ \text{nm}$$

Personnel Labor Beyond 12 nm

This MPCD requires .39 personnel hour per year for operation beyond 12 nm, as explained under Section 10.1.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{0.39\ \text{hr}}{\text{yr}} = \$9/\text{yr outside } 12\ \text{nm}$$

The labor required to transfer waste oil generated by the gravity coalescence system to a disposal facility is included in the above labor cost estimates. As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste oil at no charge for Navy vessels.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{28\ \text{gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$25/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{3.5\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$3/\text{yr}$$

Table 10-6 summarizes the annual recurring costs for a gravity coalescence system used on a WPB 110 Class vessel.

Table 10-6. Annual Recurring Costs for Gravity Coalescence (WPB 110 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.09
Beyond 12 nm	Navy	0.009
Within 12 nm	Coast Guard	0.12
Beyond 12 nm	Coast Guard	0.012

10.1.2.3 Total Ownership Cost (TOC)

Table 10-7 summarizes the TOC and annualized cost over a 15-year lifecycle of a gravity coalescer system on a WPB 110 Class vessel.

Table 10-7. TOC for Gravity Coalescence (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0	0	0
Total Recurring	1.0	1.1	1.3	1.5
TOC (15-yr lifecycle)	1.0	1.1	1.3	1.5
Annualized	0.09	0.09	.11	.13

10.2 CENTRIFUGE

The following sections discuss the feasibility and cost impacts of installing and operating a centrifuge on-board WPB 110 Class vessels.

10.2.1 Practicability and Operational Impact Analysis

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of centrifuges.

10.2.1.1 Space and Weight

WPB 110 Class vessels are equipped with one 2-gpm gravity coalescing type OWS. One 2-gpm centrifuge unit (Westfalia model OTC-2-03) is proposed in this analysis. The unit was chosen because it has a processing capacity similar to the current MPCD in place on WPB 110 Class vessels. The unit is manufactured by a major supplier of centrifuges used in the marine industry and is representative in space, weight, and power requirements of centrifuges with a similar processing capacity. Table 10-8 provides the space and weight for the centrifuge, which comes as a complete 2-gpm module.

Table 10-8. OTC-2-03 Specifications (WPB 110 Class)

Physical Properties	Number of Units	Capacity	Size (ft.) L x W x H	Maintenance Envelope (ft.)	Volume (ft^3)	Weight (lbs.) Dry/Flooded
Per unit	1	2 gpm	1.9x1.9x 1.93	2.9 x 2.9 x 3.0	7.0	132
Total (To achieve required processing capacity)	1	2 gpm	1.9x1.9x 1.93	2.9 x 2.9 x 3.0	7.0	132

The centrifuge is designed for single deck operation and could be installed in the space occupied by the existing OWS. The existing OWS would be removed and replaced with the centrifuge unit.

10.2.1.2 Personnel/Equipment Safety

Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use on Armed Forces vessels. Standard afloat control and management procedures are adequate for use and disposal of the material. While centrifuges require electrical power, observing standard shipboard safety procedures for handling electrical equipment should be adequate.

10.2.1.3 Mission Capabilities

The installation and operation of centrifuges on WPB 110 Class vessels are not expected to have an impact on ship's signature, mobility, or on any mission critical systems or operations.

10.2.1.4 Personnel Impact

The OTC-2-03 centrifuge runs in automatic mode, but still requires general supervision while the unit is operating. Based on a MPCD rated capacity of 2 gpm and the approximately 2,797 gallons of bilgewater generated annually, the number of hours the centrifuge would be operated within 12 nm is 23 hours.

$$\frac{2{,}797\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{2\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} = 23\text{ hrs/yr}$$

The labor requirement for general oversight of the centrifuge system is calculated as 0.25 hours for every two hours of operation. The supervisory labor requirement of 15 minutes for every two hours of operation is based on the assumption that although the unit is automatic, a crewmember will be assigned to general oversight of multiple pieces of equipment at once. Therefore, the annual labor requirement associated with the operation of a centrifuge within 12 nm is 2.9 hours per year.

$$\frac{23\,\text{hrs}}{\text{yr}} \bullet \frac{0.25\ \text{hr labor}}{2\ \text{hrs}} = 2.9\ \text{hrs labor/yr}$$

In addition, the waste oil removed from the bilgewater must be transferred to a shore facility. This transfer requires three crewmembers per event as described under the Section 10.1.1.4. The labor hours associated with transferring the waste oil produced by a centrifuge unit on the WPB 110 Class vessel within 12 nm of shore are calculated by dividing the waste oil volume (1 percent of the annual bilgewater volume generated within 12 nm of shore) by the waste oil pump rate (8.0 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{27.97\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{8\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{3\ \text{hrs labor}}{\text{hr}} = 0.17\ \text{hrs labor/yr}$$

The combined annual labor associated with the operational oversight of the centrifuge unit within 12 nm and transfer of waste oil generated within 12 nm on a WPB 110 Class vessel is 3 hours.

The total labor requirement associated with vessel operation beyond 12 nm includes MPCD operator oversight (i.e., 15 minutes for every two hours of equipment operation) and labor required to oversee the offloading of waste oil to shore attributable to vessel operation beyond 12 nm. The annual labor requirement associated with operating this MPCD beyond 12 nm is calculated using the same methodology used to calculate the annual labor requirement within 12 nm. Hours of MPCD operation and annual labor requirements are presented below.

Hours of MPCD operation beyond 12 nm:

$$\frac{350\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{2\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} = 2.9\ \text{hrs/yr}$$

Labor requirement for MPCD operator oversight:

$$\frac{2.9\ \text{hrs}}{\text{yr}} \bullet \frac{0.25\ \text{hrs labor}}{2\ \text{hrs}} = 0.36\ \text{hrs labor/yr}$$

Labor requirement for offloading waste oil:

$$\frac{3.5\ \text{gal}}{\text{yr}} \bullet \frac{\text{min}}{8\ \text{gal}} \bullet \frac{\text{hr}}{60\ \text{min}} \bullet \frac{3\ \text{hrs labor}}{\text{hrs}} = 0.02\ \text{hrs labor/yr}$$

Total MPCD operator labor and waste oil offloading oversight associated with the operation of a OTC-2-03 centrifuge on WPB 110 Class vessels beyond 12 nm is .39 hr/yr.

Annually, the OTC-2-03 requires approximately 6.75 personnel hours of time-based maintenance, 0 personnel hours of condition-based maintenance within 12 nm, and 0 personnel hours of condition-based maintenance beyond 12 nm. Table 10-9 and Table 10-10 and summarize the time-based and condition-based maintenance requirements, respectively, for one OTC-2-03 centrifuge.

Table 10-9. OTC-2-03 Time-Based Maintenance (WPB 110 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency	Annualized Maintenance Time (hours)
Change gear case oil, renew gaskets	2	6 months	4
Replace drive belt, check bearings	2	12 months	2
Renew sealing rings, replace bearings	1.5	24 months	0.75
Total Annualize Hours (per unit)	-	-	6.75
Total Annualize Hours (total)	-	-	6.75

Table 10-10. OTC-2-03 Condition-Based Maintenance (WPB 110 Class)

Maintenance Activity	Maintenance Time (hours)	Frequency (based on hours of MPCD operation)	Annualized Maintenance Hours (based on operation hours within 12 nm)	Annualized Maintenance Hours (based on operation hours beyond 12 nm)
None	0	0	0	0
Total Annualized Hours (per unit)	-	-	-	0
Total Annualized Hours (per vessel)	-	-	-	0

Centrifuges are equipped with programmable logic controls and monitoring systems. The oil content monitor alarm can be monitored remotely or locally.

Operator certification is not required. Inexperienced equipment operators require four to six hours of training. Properly operating centrifuges pose no impact on habitability.

Table 10-11 provides annual labor hours required for operation and maintenance of the OTC-2-03 centrifuge.

Table 10-11. Centrifuge Labor Hours (WPB 110 Class)

	MPCD Option: Centrifuge
Operator Hours (hours) Within 12 nm	3.1
Operator Hours (hours) Beyond 12 nm	0.39
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	6.75
Total Time (hours)	10.2

10.2.1.5 Consumables, Repair Parts, and Tools

Centrifuges require consumables, repair parts, and special tools. In addition, a spare parts kit is available from the vendor. Consumables and repair parts include items such as filters, gaskets, “O” rings, and bearings. The special tools required are delivered with the device and consist of spanner wrenches made specifically for dismantling the purifier bowl.

10.2.1.6 Interface Requirements

Table 10-12 lists the interfaces required to support one OTC-2-03 centrifuge.

Table 10-12. OTC-2-03 Interface Requirements (WPB 110 Class)

Shipboard System	OTC-2-03/ 2 gpm
Electrical Power	440VAC/3PH, 0.6 kW (.8 hp)
Potable Water	1 gpd

WPB 110 Class vessels are able to accommodate these interface requirements with no significant impact on existing systems.

10.2.1.7 Control System Requirements

The manufacturer recommends that the operator manually turn on the equipment. However, once the centrifuge has reached its operating speed, the OTC-2-03 does not require constant oversight.

A centrifuge will be equipped with an OCM to measure the oil content of OWS effluent. If the OCM detects an oil concentration greater than the predetermined desired concentration, the OCM will redirect the effluent back to the OWHT to be processed again by the OWS.

10.2.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

10.2.2 Cost Analysis

The following cost data and calculations are associated with a centrifuge system on the WPB 110 Class vessel.

10.2.2.1 Initial Cost

The system procurement unit cost is $6,520 per vessel (Donohue, 2000). Based on ship arrangement drawing analysis and a ship check of WPB 1344 (a WPB 110 Class vessel), the Navy estimates that installation will cost $54,770 per vessel (Navy, 2000). To install the unit, the existing gravity coalescence unit must first be removed to make space available for the centrifuge system. The installation would require approximately four weeks to complete. Technical manuals cost approximately $85,000 ($1734 per vessel) to develop a 150-page manual (Gallagher, 1999). The Navy estimates that the development of technical drawings will cost $19,000 ($388 per vessel) (Navy, 2000). The cost for training materials is approximately $9,330 ($190 per vessel) (Smith, 2001). The initial cost of a centrifuge system on a WPB 110 Class vessel is $63,600 per vessel.

10.2.2.2 Recurring Cost

Personnel Labor Within 12 nm

This MPCD requires 9.8 personnel hours per year for operation and time-based maintenance within 12 nm, as explained under Section 10.1.1.4. The number of annual labor hours multiplied by the $22.64 hourly MPCD operator labor rate produces the first operating year recurring labor cost within 12 nm.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{9.8\text{ hrs}}{\text{yr}} = \$220/\text{yr}$$

Personnel Labor Beyond 12 nm

This MPCD requires .39 personnel hour per year for operation beyond 12 nm, as explained under Section 10.2.1.4. The annual labor cost associated with operating this MPCD beyond 12 nm is calculated using the same hourly labor rate used to calculate the annual labor cost within 12 nm, as shown below.

$$\frac{\$22.64}{\text{hr}} \bullet \frac{.39\text{ hr}}{\text{yr}} = \$9/\text{yr}$$

The labor required to transfer waste oil generated by the centrifuge system to a disposal facility is included in the above labor cost estimates. As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste at no charge to Navy vessels.

Coast Guard vessels pay a fee to dispose of their waste oil. The recurring cost incurred by the Coast Guard to dispose of the waste oil generated within 12 nm is shown below.

$$\frac{28 \text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$25/\text{yr}$$

The recurring cost incurred by the Coast Guard to dispose of waste oil generated beyond 12 nm is shown below.

$$\frac{3.5 \text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$3/\text{yr}$$

Table 10-13 summarizes the annual recurring costs for a centrifuge system used on a WPB 110 Class vessel.

Table 10-13. Annual Recurring Costs for Centrifuge System (WPB 110 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	0.22
Beyond 12 nm	Navy	0.009
Within 12 nm	Coast Guard	0.25
Beyond 12 nm	Coast Guard	0.012

10.2.2.3 Total Ownership Cost (TOC)

Table 10-14 summarizes the TOC and annualized cost over a 15-year lifecycle of a centrifuge system on a WPB 110 Class vessel.

Table 10-14. TOC for Centrifuge System (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	63.6	63.6	63.6	63.6
Total Recurring	2.5	2.6	2.8	2.9
TOC (15-yr lifecycle)	66	66.1	66.4	66.5
Annualized	5.6	5.6	5.6	5.7

10.3 COLLECTION, HOLDING, AND TRANSFER (CHT)

The following sections discuss the feasibility and cost impacts of not discharging bilgewater (treated or untreated) from WPB 110 Class vessels to the environment within 12 nm from shore. This no-discharge option is referred to as the practice of CHT. The bilgewater may be transferred to shore facilities in port, processed through an OWS beyond 12 nm, or discharged overboard in accordance with applicable regulations when beyond 12 nm from shore.

For new design vessels powered by compression ignition (CI) engines, NSWCCD Code 20, Total Ship Systems Engineering Group, evaluated the feasibility and cost impacts of practicing CHT of surface vessel bilgewater.

10.3.1 Practicability and Operational Impact Analysis – Existing Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of CHT.

10.3.1.1 Space and Weight

WPB 110 Class vessels are equipped with an OWHT that has a design capacity of approximately 155 gallons. The holding tank is designed with capacity 5 percent in excess of the ship's requirements, to minimize the risk of overfilling the tank, which would result in spillage. However, common practice throughout the Coast Guard is to limit the maximum volume of bilgewater to approximately 70 percent of design capacity (i.e., 108 gallons). This allows for a margin of safety to accommodate the following scenarios without jeopardizing vessel safety or vessel missions/operations: 1) Unexpected surges in bilgewater production due to minor flooding; 2) changes in vessel mission/operations that would temporarily prohibit the operation of the OWS for periods up to 48 hours; and 3) 48 hour margin in case of an OWS casualty. This tank is designed to collect and hold oily waste (i.e., bilgewater) for processing by the vessel's 2-gpm OWS unit or for transfer to shore, as applicable. As such, WPB 110 Class vessels are capable of practicing CHT up to the existing holding capacity without experiencing any impacts to space and weight. The potential for exceeding the vessel's existing space and weight capacities, as a result of practicing CHT, will depend upon the length of time spent within 12 nm from shore, and whether the port visited has the capability to offload wastewater.

During a typical operating cycle, WPB 110 Class vessels may visit many ports for varying lengths of time. WBP 110 Class vessels typically operate their OWS units, rather than offloading their bilgewater to shore. The longest stays in port tend to be at the vessel's homeport or at other major Coast Guard ports, where full shore services, including wastewater offloading, are available. The Coast Guard uses commercial contractors to provide wastewater offloading facilities (e.g., tank trucks). To support their operational requirements (e.g., search and recovery missions, drug traffic interdiction, etc.), WPB 110 Class vessels may occasionally visit smaller ports where offloading services are not available. In this situation, a WPB 110 Class vessel could be required to collect and hold all bilgewater generated until the ship is beyond 12 nm. The following paragraphs will evaluate two potential scenarios: (1) arriving at a port where wastewater offloading services are available, and (2) arriving at a port where such services are not available.

Ports with wastewater offloading services: There are 49 WPB 110 Class patrol boats operating from over 30 different homeports around the United States and its territories. These homeports generally have complete shore services, including wastewater offloading facilities available through commercial contractors. Once a vessel has tied up pierside at one of these ports, the transfer of bilgewater to shore can be performed as needed, although Coast Guard policy does not require the transfer of bilgewater to shore because of the associated costs. WPB 110 Class vessels can also collect and hold bilgewater while transiting from 12 nm to port for transfer shoreside. The average time to transit from these ports to 12 nm from shore is 2 or 3 hours. While underway, the WPB 110 Class vessels generate approximately 25 gpd of bilgewater, or approximately 1 gallon per hour. Using a generation rate of 1 gallon per hour over 3 hours, the maximum volume of bilgewater generated during a transit would be approximately 3 gallons. Because the 3 gallons collected during transit is well within the holding capacity for WPB 110 Class patrol boats, practicing CHT while transiting to or from a port where shore offloading facilities are available will have no space or weight impacts.

Ports without wastewater offloading services: If the vessel is visiting a port where offloading bilgewater is not possible, the ship could be required to hold all bilgewater during the entire time spent within 12 nm. A typical visit to a small port may last two to five days. Assuming a five-day port visit, a WPB 110 Class vessel would generate approximately 20 gallons of bilgewater (based on in port generation rate). Using a generation rate of 1 gallon per hour and a total transit time of 6 hours (3 hours in each direction), the vessel would generate an additional 6 gallons of bilgewater while transiting to and from port. The total bilgewater generated within 12 nm from shore would be 26 gallons. Because this is within the current holding capacity of the OWHT, practicing CHT in this scenario should not result in any space and weight impacts. Under this scenario (i.e., extended port visit), a WPB 110 Class vessel could practice CHT for up to 38 days without exceeding the existing holding capacity.

Vessel operations within 12 nm of shore: Due to the nature of some U.S. Coast Guard missions, a WPB 110 Class patrol boat might be required to operate within 12 nm from shore for up to 10 days without returning to port. Using a generation rate of 25 gpd (underway generation rate) for 10 days, these patrol boats would generate approximately 250 gallons of bilgewater during this period. This quantity exceeds the holding capacity of the existing OWHT. Under operating scenarios such as this, it would not be possible for a WPB 110 Class vessel to comply with a "no-discharge" requirement, without expanding the bilgewater holding capacity. Using the OWS to process bilgewater from the bilge area as it is generated would decrease the OWS effectiveness. The OWHT acts as a pretreatment that allows the oil content to settle out of the bilgewater allowing the OWS to operate more effectively. Also, the Coast Guard tries to maintain operational flexibility by keeping, at a minimum, 30 percent of the OWHT empty at all times. Therefore the bilgewater content of the tanks is processed by the OWS once the tanks are 70 percent full.

Practicing CHT within the existing holding capability will not result in any space or weight impacts. While the above analyses describe typical operating scenarios, there may be situations where practicing CHT may exceed the vessel's existing holding capacity. Extra tank capacity would be required to accommodate any additional volume of bilgewater collected. This would result in space and weight impacts. Because the space and weight allocations on WPB 110 Class vessels are tightly controlled, there is generally very little available unassigned space to accommodate additional tankage. Therefore, the most likely strategy for increasing bilgewater holding capacity would be to convert other existing tanks to bilgewater holding tanks. However, converting existing tanks to hold bilgewater would likely result in adverse impacts to those systems or services, which rely on the tanks that would be converted for holding oily waste.

10.3.1.2 Personnel/Equipment Safety

Practicing CHT within the vessel's existing holding capacity will not pose any safety hazards to the vessel's equipment or crew.

10.3.1.3 Mission Capabilities

Practicing CHT within the vessel's existing holding capacity will not have an impact on ship's signature, war fighting capabilities, mobility, or on any mission critical systems or operations.

The ship designers review the ship's requirements (e.g., vessel's range, number of crew, etc.) to determine the tank capacities needed to allow the ship to fulfill its mission. With the exception of approximately five percent excess capacity as a margin of safety, ship designers do not size a vessel's tank capacity beyond what is necessary to meet the ship's requirements. Practicing CHT in excess of the vessel's existing holding capability would likely require that additional tanks be built or tanks used for other purposes be converted to bilgewater holding tanks. Reducing the capacity of existing tanks, such as potable water tanks or sewage tanks, will reduce the ship's current capability to support its mission.

The USCG mission often requires their vessels to operate for extended periods of time within 12 nm (e.g., search and rescue missions). The USCG may operate their OWS, as necessary and at the discretion of the Commanding Officer, to prevent bilgewater accumulation in excess of the vessels' current holding capacity and minimize mission impacts. In instances where a USCG vessel is at risk of exceeding its bilgewater holding capacity (e.g., during extensive operations within 12 nm), requiring USCG vessels to practice CHT without the flexibility of processing bilgewater through the OWS would have a significant mission impact. Specifically, if a USCG vessel were required to practice CHT and was at risk of exceeding its current holding capacity, it would have to return to shore to offload bilgewater thus forcing the vessel to discontinue critical mission-related activities.

10.3.1.4 Personnel Impact

Practicing CHT within the vessel's existing holding capacity will not result in any personnel impacts other than time required to oversee the transfer of bilgewater and oily waste to shore (see analysis below).

Practicing CHT as a primary control option does not require additional special training. Manning is required to oversee the transfer of bilgewater to a shore facility or receiving vessel (i.e., operate the OWT pump and associated valves/hull connections). This transfer requires three crewmembers per event as described in the Section 10.1.1.4. WPB 110 Class vessels generate 2797 gallons of bilgewater annually with 12 nm. The labor hours associated with transferring the waste oil are calculated by dividing the waste oil volume (1 percent of the annual volume of bilgewater generated within 12 nm of shore) divided by the OWT pump rate (120 gpm) and multiplying by the number (three) of crewmembers.

$$\frac{2{,}797\text{ gal}}{\text{yr}} \bullet \frac{\text{min}}{120\text{ gal}} \bullet \frac{\text{hr}}{60\text{ min}} \bullet \frac{3\text{ hrs labor}}{\text{hr}} = 1.2\text{ hrs labor/yr}$$

Table 10-15 provides the annual labor hours required for CHT

Table 10-15. CHT Annual Labor Hours (WPB 110 Class)

	MPCD Option: CHT
Operator Hours Within 12 nm	1.2
Operator Hours Beyond 12 nm	0
Condition-based Maintenance Within 12 nm	0
Condition-based Maintenance Beyond 12 nm	0
Time-based Maintenance	0
Total Time	1.2

WPB Class vessels are able to accommodate these interface requirements with no significant impact on existing systems.

10.3.1.5 Consumables, Repair Parts, and Tools

There are no requirements for consumables, repair parts, or tools associated with CHT.

10.3.1.6 Interface Requirements

Practicing CHT does not require any unique interface requirements. OWT pumps and associated valves, piping, and hull connections exist on this vessel class to support CHT.

10.3.1.7 Control System Requirements

There are no new automated control system requirements associated with CHT. However, crewmembers are required to watch for oily wastewater spills, as discussed in Section 10.1.1.4.

10.3.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option.

10.3.2 Cost Analysis – Existing Vessels

The following cost data and calculations are provided to allow the reader to compare relative costs associated with practicing CHT on a WPB 110 Class vessel. CHT is generally not practiced beyond 12 nm from shore; therefore, CHT costs are calculated for operation within 12 nm only. Vessels in this class will continue to comply with appropriate regulations when operating beyond 12 nm.

10.3.2.1 Initial Cost

As described in the previous section, the reallocation of tank space to increase bilgewater holding capacity on a WPB 110 Class vessel would result in adverse impacts on mission capabilities and personnel. For the cost analysis, it was assumed that current bilgewater holding capacity is adequate. Therefore, the initial cost of acquisition and installation of additional equipment such as tankage and piping systems is assumed to be zero.

10.3.2.2 Recurring Cost

Practicing CHT requires 1.2 personnel hours per year for operation within 12 nm of shore, as explained under Section 10.3.1.4. The annual labor hours multiplied by the $22.64 per hour MPCD operator labor rate produces an annual labor cost of $26.

$$\frac{\$22.64}{\text{hr labor}} \bullet \frac{1.2\text{ hr labor}}{\text{yr}} = \$26/\text{yr}$$

The annual bilgewater generation rate within 12 nm is 2,797 gallons. Multiplying the volume of bilgewater generated annually within 12 nm by the oily waste disposal unit cost produces an annual recurring disposal cost of $2,545.

$$\frac{2{,}797\text{ gal}}{\text{yr}} \bullet \frac{\$0.91}{\text{gal}} = \$2{,}545/\text{yr}$$

There are a number of other Armed Forced vessels within the WPB 110 vessel grouping. The annual recurring disposal cost for a Navy vessel (based on disposal rates paid by the Navy), would be $210.

$$\frac{2{,}797\text{ gal}}{\text{yr}} \bullet \frac{\$0.0749}{\text{gal}} = \$210/\text{yr}$$

Table 10-16 summarizes the annual recurring costs for practicing CHT on a WPB 110 Class vessel.

Table 10-16. Annual Recurring Costs for CHT (WPB 110 Class)

Vessel Operating Parameter	Disposal Cost Used	Annual Recurring Cost ($K)
Within 12 nm	Navy	.236
Beyond 12 nm	Navy	0
Within 12 nm	Coast Guard	2.572
Beyond 12 nm	Coast Guard	0

10.3.2.3 Total Ownership Cost (TOC)

Table 10-17 summarizes the TOC and annualized cost over a 15-year lifecycle of practicing CHT on a WPB 110 Class vessel.

Table 10-17. TOC for CHT (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	0	0	0	0
Total Recurring	2.63	2.63	28.66	28.66
TOC (15-yr lifecycle)	2.63	2.63	28.66	28.66
Annualized	.223	.223	2.436	2.436

10.3.3 Practicability and Operational Impact Analysis - New Design Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of practicing CHT on new design vessels.

10.3.3.1 Space and Weight

Ports with wastewater offloading services: As discussed in Section 10.3.1.1, practicing CHT while tied up pierside or transiting to or from a port where shore offloading facilities are available (assuming a typical transit time of two to three hours) will have no space or weight impacts.

Ports without wastewater offloading services: As discussed in Section 10.3.1.1, the current holding capacity of the OWHT is sufficient to hold all bilgewater generated during an extended port visit (typically two to five days) at a port where shore offloading facilities are not available. In this scenario, practicing CHT will have no space or weight impacts.

Vessel operations within 12 nm of shore: As discussed in Section 10.3.1.1, WPB Class vessels may be required to operate within 12 nm of shore for up to ten days without returning to port. Based on typical operating scenarios and bilgewater generation rates, NSWCCD Code 20 determined that a tank (or series of tanks) with a capacity of approximately 330 gallons would be required to hold all bilgewater generated over a ten-day operating period. This is greater than twice the size of the existing OWHT capacity. To support this additional tank volume, the total ship weight would have to be increased approximately 1.4 long tons (LT), requiring an additional 0.8 LT of steel and 12 inches in overall ship length. This increase represents less than a 1 percent increase in full load weight over a current WPB 110 Class vessel, and equates to approximately 290 cubic feet in volume, of which only 44 cubic feet is occupied by the increased CHT capacity. The remaining space could not be used to increase the ship's capability unless there was no additional weight increase. NSWCCD Code 20 determined that this is not a significant increase, and that it would not have a significant impact on performance (Navy, 2003f).

10.3.3.2 Personnel/Equipment Safety

Practicing CHT on new design vessels will not pose any safety hazards to vessel equipment or crew.

10.3.3.3 Mission Capabilities

Practicing CHT will not impact mission-related operational capability of Navy vessels (Navy, 2003f).

USCG vessels do not generally operate within 12 nm for more than ten days at a time. However, some operating scenarios (e.g., search and rescue missions) may require USCG vessels to operate for extended periods within 12 nm. Despite the flexibility afforded by new design vessels (e.g., ability to increase the OWHT capacity in response to the majority of operating scenarios), new design vessels are not expected to be able to fully practice CHT for all operating scenarios (e.g., search and rescue missions of extended duration).

10.3.3.4 Personnel Impact

Practicing CHT would require approximately three crewmembers per event to conduct the transfer of oily wastes to shoreside facilities. Practicing CHT on new design vessels is expected to require 1.2 total hours of labor per year, and will not result in any significant impact on personnel (Navy, 2003f).

10.3.3.5 Consumables, Repair Parts, and Tools

There are no requirements for consumables, repair parts, and tools associated with practicing CHT on new design vessels.

10.3.3.6 Interface Requirements

Practicing CHT on new design vessels will not have an impact on interface requirements. OWT pumps and associated valves, piping, and hull connections would be designed into new design vessels (Navy, 2003f).

10.3.3.7 Control System Requirements

Practicing CHT on new design vessels will not have an impact on control system requirements (Navy, 2003f).

10.3.3.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to practicing CHT on new design vessels.

10.3.4 Cost Analysis – New Design Vessels

The following cost data and calculations are provided to allow the reader to compare relative costs associated with practicing CHT on a new design vessel in this vessel group. CHT is generally not practiced beyond 12 nm from shore; therefore, CHT costs are calculated for operation within 12 nm only. Vessels in this class must continue to comply with appropriate regulations when operating beyond 12 nm.

NSWCCD Code 20 estimated the total initial, total recurring, total ownership cost (TOC), and annualized costs for practicing CHT on new design vessels in this vessel group. Table 10-18 summarizes those costs below.

10.3.4.1 Initial Cost

The required increase in OWHT volume (330 gallons vs. 155 gallons) would require new design vessels in this vessel group to add 0.8 LTs of additional steel, adding approximately $52,000 to the initial acquisition cost of each ship. Therefore, the total acquisition cost of equipping one new design vessel in this group to practice CHT is estimated to be $52,000 (Navy, 2003f).

10.3.4.2 Recurring Cost

Practicing CHT requires 1.2 total labor hours per year for operation, as explained in Section 10.3.1.4. The labor and disposal costs associated with bilgewater disposal are estimated to be $240 annually for the Navy. The labor and disposal costs associated with bilgewater disposal are estimated to be $2,600 annually for the Coast Guard (Navy, 2003f).

10.3.4.3 Total Ownership Cost (TOC)

Table 10-18 summarizes the TOC and annualized cost over a 15-year lifecycle of practicing CHT on a WPB 110 Class vessel.

Table 10-18. TOC for CHT system On New Design Vessels (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	52	52	52	52
Total Recurring	2.6	2.6	29	29
TOC (15-yr lifecycle)	56	56	81	81
Annualized	4.6	4.6	6.9	6.9

10.4 EVAPORATION

The largest bilgewater evaporator can process bilgewater at a maximum rate of one gallon per minute. The largest evaporator was chosen for this analysis to minimize the number of units required. Therefore, one evaporation unit would be required to meet the current oily water separator processing capacity. However, based on the review of ship drawings, the Navy's Alteration and Installation Team (AIT) has concluded that there is not adequate space on the WPB 110 Class vessel to reconfigure equipment to accommodate one evaporator (Navy, 2000).

Therefore, no further analysis will be conducted with regard to the use of an evaporation system on WPB 110 Class vessels.

Furthermore, despite the flexibility afforded by new design vessels (e.g., reduced cost of forward-fit installation), new design vessels are not expected to be able to support the evaporators' substantial power requirements. Therefore, based on the evaporators' power requirements that subsequently degrade the vessel's mission and safety capabilities, evaporation is not a feasible MPCD option group for either existing or new design vessels represented by the WPB 110 Class. In addition, design concerns such as adequate size, corrosivity, plating out of salt in the unit, and buildup of salt and sludge still need to be addressed before this technology may be feasible on this vessel class.

10.5 HYDROCYCLONES

Based upon information provided by the Coast Guard, these vessels cannot provide the compressed air required to operate a hydrocyclone system. WPB 110 Class vessels are not equipped with air compressors, and due to their weight-critical status they cannot absorb the additional weight of a compressed air system installation (Volpe, 2001). Hydrocyclones use pneumatic control systems that require compressed air in order to operate. Therefore, the use of hydrocyclones is infeasible and no further analysis will be conducted with regard to the use of hydrocyclones on WPB 110 Class vessels.

10.6 IN SITU BIOLOGICAL TREATMENT

In Situ biological treatment of bilgewater is the addition of microbes to a vessel's bilge spaces to digest the oil content of the bilgewater. For *in situ* biological treatment to be effective, the microbes must be left in the bilge for a sufficient period of time to digest the bilgewater's oil content. According to the vendor, the most effective use of *in situ* biological treatment for the wastewater that accumulates in the bilge is to leave the *in situ* material in the bilge spaces on the vessel for a 30-day period to establish a population of microbes (Opsanick, 2000). Transferring bilgewater to shore or allowing additional bilgewater to be introduced to the bilge spaces before the 30-day period is complete may decrease the *in situ* biological treatment's effectiveness. Due to the lack of performance data, the extent to which the effectiveness of biological treatment would be decreased cannot be determined (Opsanick, 2000). However, the vessel would be continuously generating bilgewater during this period, disrupting the batch processing method recommended by the manufacturer. Therefore, *in situ* biological treatment is not a feasible MPCD option group for existing or new design vessels represented by WPB 110 Class vessels.

10.7 OIL ABSORBING SOCKS (OASS)

OASs are designed to absorb oil floating on the surface of a body of water (Sorbent Products, Inc., 2000). In this application, OASs would be placed inside the bilge areas of a WPB 110 Class vessel to continuously absorb the waste oil from the bilgewater. When the OAS becomes fully saturated, they are manually removed and replaced with a new OAS. This use of OASs for WPB 110 Class vessels poses concerns regarding its potential effects on emergency dewatering and its potential as a concentrated fuel source that could contribute to the intensity of an engine room fire.

The presence of OASs in the bilge spaces would potentially restrict the flow of bilgewater through the normal and emergency dewatering pumps and strainers by clogging the suction points. The use of OASs in the bilge spaces of both U.S. Coast Guard and Navy vessels would not be feasible due to vessel safety and survivability concerns. Both services prohibit (through practice) the presence of any loose materials or debris in the bilge areas that could potentially interfere with normal or emergency dewatering activities. Securing the OASs to a pipe or other type of fixture in the bilge is not feasible because the force of a shock or explosion would potentially dislodge the OAS. Furthermore, as the OAS absorbs oil it becomes a concentrated fuel source for a fire that could contribute to the intensity of an engine room fire.

Based on the potential operational and safety impacts related to emergency dewatering, and to potential fire hazards, OASs are not a feasible MPCD option group on WPB 110 Class vessels. New design vessels cannot resolve these impacts.

10.8 FILTER MEDIA

Based on a review and analysis of the WPB 110 Class arrangement drawings, the Navy's AIT has concluded that adequate space is not available on existing WPB 110 Class vessels to accommodate a filter media system (Navy, 2000). This vessel class is too small to reconfigure existing critical equipment to make space for filter media systems. Also, the OWS filter media polishing systems were installed on two DDG 51 Class destroyers and were removed because they failed to consistently produce an effluent with an oil content less than 15 parts per million (Hopko, 1996). Navy ships with OWSs and Oil Content Monitors should attempt to limit oil and oily discharges to 15 ppm oil worldwide (Navy, 2002). Therefore, use of filter media is infeasible and no further analysis will be conducted with regard to the use of filter media on WPB 110 Class vessels.

NSWCCD Code 20, Total Ship Systems Engineering Group, evaluated the feasibility and cost impacts of installing and operating filter media polishing units on small, new design vessels powered by compression ignition (CI) engines. The DDG 51 existing vessel feasibility impact analysis report (FIAR) supported this new design analysis because the filter media polishing unit on the DDG is the same as the filter media polishing unit analyzed for new design vessels in the WPB vessel group.

10.8.1 Practicability and Operational Impact Analysis – New Design Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of a filter media polishing unit.

10.8.1.1 Space and Weight

The installation of a filter media polishing unit would require new design vessels in this vessel group to accommodate additional deck area, and the 0.3 LT system weight of the filter media polishing unit evaluated. To accommodate the volume and weight of the filter media polishing unit, the hull size would have to be increased. In order to maintain the full beam of 21 ft, this required hull expansion results in the addition of four inches to the overall length of the ship. Increasing the ship’s size to support the additional weight would require approximately 0.4 LT of additional structure. Therefore, the total weight increase would be 0.7 LT, which is a 0.5 percent increase in full load weight over a current WPB 110 Class vessel (Navy, 2003g).

10.8.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with the filter media polishing unit. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary. Any hazardous materials (e.g., oil and grease) required for operation and maintenance are minimal in quantity and authorized for use. Standard afloat control and management procedures are adequate for use and disposal of the material.

10.8.1.3 Mission Capabilities

Filter media polishing unit equipment will not impact mission-related operational capability (Navy, 2003g).

10.8.1.4 Personnel Impact

Based on the assumptions and methodologies used to analyze MPCD feasibility on existing vessels, NSWCCD Code 20 determined the operation and maintenance of filter media systems on new design vessels would require 0.01 total hours of labor per vessel, per year. This labor requirement will not result in any significant impact on personnel (Navy, 2003g).

10.8.1.5 Consumables, Repair Parts, and Tools

The filter media canisters will require replacement once every 2 years (Volpe, 2002). The filter media polishing unit on certain DDG 51 Class vessels requires the replacement of nine filter media canisters. The canisters may be stored on the vessel or shoreside. No special tools are required to operate or maintain the units.

10.8.1.6 Interface Requirements

The operation of the filter media polishing unit will not change the load on the electrical plant. Therefore, no specific interface requirement impact is associated with the filter media polishing unit (Navy, 2003g).

10.8.1.7 Control System Requirements

The filter media system operates automatically in response to the primary OWS operation. Therefore, the filter media polishing unit does not have any unique control system requirements. Because the installation and operation of a filter media system on existing vessels does not impact control system requirements, it is not expected to impact these systems on similar new design vessels.

10.8.1.8 Other/Unique Characteristics

As determined in the DDG feasibility analysis for existing vessels, the filter media polishing units installed on DDG 59 and DDG 61 (DDG 51 Class vessels) were removed because they failed to consistently produce an effluent with an oil content of less than 15 parts per million. Because the operation of the filter media polishing unit tested for existing vessels failed to consistently produce an effluent with an oil content of less than 15 parts per million, it would be expected to have the same performance problems on similar new design vessels. Further development of this technology for shipboard bilgewater application could resolve this reliability concern.

10.8.2 Cost Analysis – New Design Vessels

The following cost data and calculations are provided to allow the reader to compare costs associated with a filter media system on a new design vessel in this vessel group.

NSWCCD Code 20 estimated the total initial, total recurring, TOC, and annualized costs for installing filter media polishing units on new design vessels in this vessel group. Table 10-19 summarizes those costs below.

10.8.2.1 Initial Cost

NSWCCD Code 20 estimates that the filter media polishing unit procurement cost is $15,000 per vessel, and estimates that installation of the unit will cost $45,700 per vessel. In addition, increasing the length of the vessel by 4 inches to accommodate the filter media polishing unit would add an additional $25,200 (cost of 0.4 LT of steel) to the initial acquisition cost of each ship. Nonrecurring costs (e.g., technical manuals, drawings, training materials, etc.) will cost $2,200 per vessel. The total acquisition cost of a filter media system for new design vessels in this vessel group is estimated to be $88,100 (Navy, 2003g).

10.8.2.2 Recurring Cost

The filter media system requires 0.01 total personnel hours per year, as explained in Section 10.8.1.4. The labor and consumable costs associated with filter media polishing units are estimated to be $3,500 annually for both the Navy and the Coast Guard (Navy, 2003g). The filter media polishing unit does not require the transfer of waste oil because the filter media canisters absorb the oil content of the oily bilgewater. Therefore, the filter media polishing unit does not produce waste oil that must be offloaded from the vessel.

10.8.2.3 Total Ownership Cost (TOC)

Table 10-19 below summarizes the TOC and annualized cost over a 15–year lifecycle for a filter media system on a new design vessel in this vessel group.

Table 10-19. TOC for Filter Media System on New Design Vessels (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	88.1	88.1	88.1	88.1
Total Recurring	39	39	39	39
TOC (15-yr lifecycle)	127	127	127	127
Annualized	10.8	10.8	10.8	10.8

10.9 MEMBRANE FILTRATION

Based on a review and analysis of the WPB 110 Class arrangement drawings, the Navy's AIT has concluded that adequate space is not available on WPB 110 Class vessels to accommodate an ultrafiltration (UF) membrane system (Navy, 2000). This vessel class is too small to reconfigure existing critical equipment to make space for a membrane system. Therefore, use of membrane filtration is infeasible and no further analysis will be conducted with regard to the use of membrane filtration on WPB 110 Class vessels.

NSWCCD Code 20, Total Ship Systems Engineering Group, evaluated the feasibility and cost impacts of installing and operating UF membrane systems on small, new design vessels powered by compression ignition (CI) engines. As discussed above, UF membrane systems are not feasible aboard existing WPB 110 Class vessels. However, NSWCCD Code 20 assumed that the 10-gal/min UF system analyzed in the DDG 51 feasibility analysis would be an appropriate unit for potential installation on new design vessels. This assumption is based on the fact that it is the smallest existing system capable of processing at a rate of 2-gal/min or higher. The analysis presented below would likely overestimate the feasibility impacts of a 2-gal/min system, if such a system were developed.

10.9.1 Practicability and Operational Impact Analysis – New Design Vessels

This section analyzes specific feasibility criteria relative to the physical characteristics and operational requirements of a UF membrane system.

10.9.1.1 Space and Weight

The installation of a UF membrane system would require new design vessels in this vessel group to accommodate an additional 35 ft^2 of deck area and the 1.2 long tons (LT) system weight of the smallest available membrane system under development. The additional 35 ft^2 of deck area would require adding approximately 20 inches to the overall length of the ship while maintaining the full beam of 21 ft. Increasing the ship's size to support the additional weight would require approximately 1.4 LT of additional structure. Therefore, the total weight increase would be 2.6 LT, which is a 1.7 percent increase in full load weight over a current WPB 110 Class vessel (Navy, 2003h).

10.9.1.2 Personnel/Equipment Safety

There are no unusual personnel or equipment safety hazards associated with UF membrane systems. Other than wearing standard personal protective equipment (e.g., rubber gloves/boots and safety glasses/goggles) during maintenance activities, no special devices or precautions are necessary.

10.9.1.3 Mission Capabilities

Membrane filtration equipment will not impact mission-related operational capability (Navy, 2003h).

10.9.1.4 Personnel Impact

Based on the assumptions and methodologies used to analyze MPCD feasibility on existing vessels, NSWCCD Code 20 determined the operation and maintenance of UF membrane systems on new design vessels would require 2.6 total labor hours per vessel, per year. This labor requirement will not result in any significant impact on personnel (Navy, 2003h).

10.9.1.5 Consumables, Repair Parts, and Tools

Membranes are scheduled for replacement after approximately 2400 hours of use. At this time, a clean set of membranes is put in the UF system and the old, used set is sent to shore to be cleaned. This regular maintenance does not require any consumables, as the membranes are exchanged. Furthermore, no special tools are required to operate or maintain the units.

10.9.1.6 Interface Requirements

The installation and operation of a UF membrane system on new design vessels would increase the load on the electrical plant by approximately 5 kW. Because the UF membrane system is expected to operate less than 5 minutes every 24 hours, this additional electrical load is not significant (Navy, 2003h).

Table 10-20 summarizes the UF membrane system interface requirements.

Table 10-20. Membrane Filtration Interface Requirements (WPB 110 Class)

Shipboard System	Interface Requirement (10 gpm system)
Electric Power	440 Volts/3 Phase/ 60Hz/7.5 kW (10 hp)
Compressed Air	80 to 100 psig, 5 scfm (to operate valve actuators)
Potable Water	Fresh water back flush of membranes 10-gpm, 30 psig
Drainage	Concentrate from Recirculation Sub-system drains to WOT. When back flushing membranes, oily waste flushed from system is diverted to OWHT.

10.9.1.7 Control System Requirements

The UF membrane system operates automatically in response to the primary OWS operation. Therefore, the UF membrane system does not have any unique control system requirements. Because the installation and operation of a UF membrane system on existing vessels does not impact control system requirements, it is not expected to impact these systems on similar new design vessels.

10.9.1.8 Other/Unique Characteristics

No other/unique characteristics have been identified with respect to this MPCD option. Because the installation and operation of a UF membrane system on existing vessels does not impact any other/unique characteristics, it is not expected to impact these characteristics on similar new design vessels.

10.9.2 Cost Analysis – New Design Vessels

The following cost data and calculations are provided to allow the reader to compare costs associated with a UF membrane system on a new design vessel in this vessel group.

NSWCCD Code 20 estimated the total initial, total recurring, TOC, and annualized costs for installing UF membrane systems on new design vessels in this vessel group. Table 10-21 summarizes those costs below.

10.9.2.1 Initial Cost

NSWCCD Code 20 estimates that the UF membrane system (i.e., one unit) procurement cost is $200,000 per vessel, and estimates that installation of the unit will cost $52,000 per vessel. In addition, increasing the length of the vessel by 20 inches to accommodate the membrane system would add an additional $94,000 (cost of 1.4 LT of steel) to the initial acquisition cost of each ship. Nonrecurring costs (e.g., technical manuals, drawings, training materials, etc.) will cost $2,400 per vessel. The total acquisition cost of a UF membrane system for new design vessels in this vessel group is estimated to be $348,000 (Navy, 2003h).

10.9.2.2 Recurring Cost

The UF membrane system requires 2.6 total labor hours per year, as explained in Section 10.9.1.4. The labor and disposal costs (including waste oil transfer costs) associated with bilgewater disposal are estimated to be $150 annually for both the Navy and the Coast Guard (Navy, 2003h).

The labor required to transfer waste oil, generated by the UF membrane system, to a disposal facility is $25 for Coast Guard vessels (Navy, 2003h). As explained in Section 1.1.2, the disposal facility is assumed to dispose of the waste oil at no charge for Navy vessels (Navy, 2003h).

10.9.2.3 *Total Ownership Cost (TOC)*

Table 10-21 summarizes the TOC and annualized cost over a 15–year lifecycle for a UF membrane system on a new design vessel in this vessel group.

Table 10-21. TOC for UF Membrane System On New Design Vessels (WPB 110 Class)

Cost ($K)	Other Military Services Vessel Operation Within 12 nm	Other Military Services Vessel Operation Within + Beyond 12 nm	USCG Vessel Operation Within 12 nm	USCG Vessel Operation Within + Beyond 12 nm
Total Initial	348	348	348	348
Total Recurring	0.65	0.65	0.93	0.93
TOC (15-yr lifecycle)	348	348	349	349
Annualized	30.0	30.0	30.0	30.0